SLOVENSKI STANDARD
SIST EN 16834:2019

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Železniške naprave - Zavore - Značilnosti zavore

Railway applications - Braking - Brake performance

Bahnanwendung - Bremse - Bremsleistung

Applications ferroviaires - Freins - Performance de freinage

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45.040	Materiali in deli za železniško tehniko	Materials and components for railway engineering

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Railway applications - Braking - Brake performance

Applications ferroviaires - Freins - Performance de freinage

Bahnanwendungen - Bremse - Bremsvermögen

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Contents

Page

European foreword

This document (EN 16834:2019) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2019, and conflicting national standards shall be withdrawn at the latest by October 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document.

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1 Scope

This document defines a harmonized way to assess the braking performance by test of locomotives, passenger coaches, freight wagons and self-propelled passenger trains (EMU/DMU).

The document sets out the standardized method for undertaking brake performance tests and the correction factors to be applied to the data obtained for all types of rolling stock.

This document also defines the methods to assess the brake performance in terms of stopping distance, and from this the process to determine vehicle(s) deceleration and braked weight.

It then deals with conversion of the braked weight to the braked weight percentage of a vehicle or train for operating purposes. It also sets out additional factors when determining the braked weight percentage of a train calculated from specified braked weight, depending on the formation of the train.

In Annex D there is a method for determining brake performance of freight wagons fitted with P10 cast iron or LL-blocks using limited testing (force measurement).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14198, *Railway applications — Braking — Requirements for the brake system of trains hauled by locomotives*

EN 14478, *Railway applications — Braking — Generic vocabulary*

EN 14531-1, *Railway applications — Methods for calculation of stopping and slowing distances and immobilization braking — Part 1: General algorithms utilizing mean value calculation for train sets or single vehicles*

EN 14531-2:2015, *Railway applications — Methods for calculation of stopping and slowing distances and immobilization braking — Part 2: Step by step calculations for train sets or single vehicles*

EN 15355, *Railway applications — Braking — Distributor valves and distributor-isolating devices*

EN 15595, *Railway applications — Braking — Wheel slide protection*

EN 15663, *Railway applications — Vehicle reference masses*

EN 15877-1, *Railway applications — Marking on railway vehicles — Part 1: Freight wagons*

EN 15877-2, *Railway applications — Markings of railway vehicles — Part 2: External markings on coaches, motive power units, locomotives and on track machines*

EN 16207, *Railway applications — Braking — Functional and performance criteria of Magnetic Track Brake systems for use in railway rolling stock*

EN 16452, *Railway applications — Braking — Brake blocks*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14478, EN 14198 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
brake assessment speed
brake initiation speed which is decisive for determination of brake performance

Note 1 to entry: In general the initiation speed leading to the lowest braked weight.

3.2
braked weight
representative quantity for the mean braking capacity of the vehicle or train, expressed in tons, which is always expressed as a whole number

Note 1 to entry: It is displayed on the vehicle (in accordance with EN 15877-1 and EN 15877-2). Braked weight corresponds to the retardation effort and is currently expressed and designated as "B".

3.3
braked weight percentage
quotient of braked weight and vehicle mass × 100

Note 1 to entry: Also known as λ (lambda).

3.4
maximum braking load
load condition lower or equal to "design mass under exceptional payload" as defined in EN 15663 in accordance with the related vehicle standard (e.g. EN 16185-1, EN 14198)

3.5
minimum load
load condition "design mass in working order" (as defined in EN 15663)

3.6
normal load
load condition "design mass under normal payload" (as defined in EN 15663)

3.7
fully certified and exchangeable LL-block
LL-block, which fulfils all UIC requirements including exchangeability with P10 (as listed in ERA document ERA/TD/2009-02/INT)

3.8
K-block
brake block with "K"-friction materials as defined in EN 16452

3.9
EN-UIC brake
brake system as defined in EN 14198

4 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations in Table 1 apply.

Table 1 — Symbols and abbreviations

Symbol	Description	Unit
a	deceleration	m/s²
B	braked weight	t
C	constant for calculating the λ values	—
D	constant for calculating the λ values	—
d	diameter	mm
F	force	kN
g	acceleration due to gravity	9,81 m/s²
i	gradient	‰
k	assessment factor for determining the braked weight	—
m	mass of the test train or test vehicle	t
r	radius	mm
s	total stopping distance (up to $v = 0$)	m
t	time	s
v	speed	km/h
λ	braked weight percentage	%
ρ	coefficient of inertia of rotating masses	—
σ_n	standard deviation of test result	m
τ	adhesion	—
μ	coefficient of friction	—
η	efficiency of brake rigging	—
ATP	Automatic Train Protection	
Bg	brake block type Bg (single block)	
Bgu	brake block type Bgu (double brake block)	
DMU	Diesel Multiple Unit	
ep-brake	electropneumatic brake	
EMU	Electric Multiple Unit	
ETCS	European Train Control System	

Symbol	Description	Unit
G	brake mode of the slow-acting brake (freight train)	
K	brake block material in accordance with EN 16452	
L	brake block material in accordance with EN 16452	
LL	brake block material in accordance with EN 16452	
Mg	magnetic track brake	
P	brake position of quick-acting brake (passenger train)	
P+E	brake position P + electrodynamic brake	
P+H	brake position P + hydrodynamic brake	
P+Mg	brake position P + magnetic track brake	
P10	material designation of the cast-iron block with a 1 % phosphorus content	
◈	brake position in accordance with EN 14198	
R	brake position in accordance with EN 14198	
R+E	brake position R + electrodynamic brake	
R+H	brake position R + hydrodynamic brake	
R+Mg	brake position R + magnetic track brake	
S	train related brake performance category in accordance with EN 14198	
SS	train related brake performance category in accordance with EN 14198	
Sbb	brake accelerator	
Wb	eddy current brake	

5 Principles of determining the brake performance

5.1 General

The object of defining the brake performance of railway brakes is to characterize the braking capabilities of railway vehicles.

To determine the brake performance three methods of brake assessment can be used: stopping distance, braked weights, and deceleration. All three will determine the brake performance.

From vehicle testing, braked weight is derived from stopping distance. For freight wagons (fitted with cast iron blocks or fully certified and exchangeable LL-blocks) the braked weight may be calculated as set out in Annex D, if applicable.

Brake performance assessment is defined based on a number of standardized conditions (e.g. level track, dry rail and mean in-service vehicle condition). Brake assessment thus does not assume the worst possible vehicle condition, which can be the result of e.g. braking force tolerances, friction coefficient scatter, downgraded efficiency, or the failure of brake system components etc.

These brake performances do not contain safety margins.

For vehicle having different brake positions as described in EN 14198, there shall be an assessment for each brake position.

The brake performance marked on vehicles (EN 15877-1 and EN 15877-2) shall be derived from the performance determined by tests and/or calculation according to this document.

Links between calculation of brake performance and test are given in Table 2.

Table 2 — Links between calculation of brake performance and test

Vehicle type	Calculation	Brake performance	Validation by test
All vehicles excluding freight wagons	EN 14531-1 and/or EN 14531-2	Decelerations + response time / stopping distance ↑ ↓ Braked weights	mandatory
freight wagons	EN 14531-1 and/or EN 14531-2 or Annex D, if applicable (cast iron / certified LL-blocks)	Stopping distance ↑ ↓ Braked weights	mandatory (with exception of freight wagons, where the requirements of Annex D are met)

5.2 Brake assessment with braked weights

This method originated after the introduction of the compressed air brake. For this purpose a huge number of test runs on level track had been performed with a given passenger train with 60 wheelsets, defined brake equipment and given mass from various initial speeds.

The brake performance of this train has been ever since equivalent to λ = 100 % and serves as reference standard deceleration so that per definition the braked weight is equivalent to the mass of the train. The results of further tests with different brake settings set up brake assessment charts providing the relations:

$$\lambda = f\left(v, s\right) \tag{1}$$

where

s stopping distance, expressed in m;

v initial speed, expressed in km/h;

λ brake weight percentage, expressed in %.

The reference train was equipped with block brakes with low-phosphorus cast-iron blocks.

A **brake assessment diagram** is used as a basis of reference for determining the brake performance of new vehicles using the passenger brake mode.

The assessment diagrams (see Figure A.1 and B.1) are applicable for an initial braking speed of up to 200 km/h.

The braked weight is expressed in tons. The quotient obtained from the sum of all the braked weights and the mass of the train multiplied by 100 gives the braked weight percentage λ of the train and relates to the stopping distance in the event of an emergency brake application.

The braked weights assigned to the individual vehicles or vehicle segments are normally to be marked on the outside of the vehicles in accordance with EN 15877-1 and EN 15877-2 when they are obtained from brake application by brake pipe only. Braked weights shall be indicated in whole numbers of tons,

with values < 0,5 to be rounded down and values ≥ 0,5 to be rounded up. If the results come from tests on a train, the figures are initially rounded up or down for the smallest unit (wagon) on which a braked weight is indicated.

5.3 Brake assessment with deceleration's method

The brake performance of trains can be expressed by decelerations. This method may be applied for all speed ranges. For speeds over 200 km/h, it is mandatory.

The real train deceleration profile is approximated by a function with equivalent brake response time and one or more speed intervals of constant decelerations.

The deceleration method set out in this document is intended to describe the train deceleration in a simplified set of values and not by the individual braking functions.

6 Execution of tests

6.1 Test methods

6.1.1 General

The tests shall be performed by a competent authority.

NOTE As an example, a test institute in accordance with EN ISO/IEC 17025.

Train testing is the original method, which gives more accurate results and is always applicable. In the following cases, the train test can be replaced by single vehicle test, which leads to more restrictive results:

— for coaches with maximum speed ≤ 160 km/h;

— for coaches with only one stage of braking effort and maximum speed up to 200 km/h (special evaluations rules: see braked weight assessment 8.3);

— for freight wagons;

— for locomotives;

— for single EMU/DMUs (as defined in EN 16185-2).

6.1.2 Freight wagons and coaches

If the braked weight of freight wagons/coaches is determined by testing with a train, the following special conditions apply:

— coaches: For the purpose of the tests a 400 m long hauled train should be used comprising identical coaches with the same brake equipment;

— freight wagons: For the purpose of the tests a 500 m long hauled train should be used comprising identical freight wagons with the same brake equipment;

— in both cases the locomotive brake shall be isolated and all brake pipe accelerators and the EP assist shall be deactivated.

6.1.3 Locomotives

When determining the braked weight of the locomotive in position G, tests from 100 km/h in position P shall be undertaken with the locomotive operating on its own. For all other brake positions, the testing shall be done as set out in 6.3.

Locomotives with multiple brake control architecture shall be tested in all operating modes (e.g.: UIC brake pipe, direct ep-brake, rescue- or towing-mode, etc.).

6.1.4 EMU/DMU and high speed trainsets

The brake performance of a multiple unit is determined by dynamic tests for all existing brake positions with all brakes active. To determine the brake performance in degraded modes dynamic tests shall be performed for all relevant cases (e.g. isolated parts of air brake, ep assist, dynamic brake, magnetic track brake).

For trainsets which can be coupled together to operate in multiple units, the tests shall be conducted in the most unfavourable train configuration (considering the equivalent brake response time in Annex E) determined by the static test (i.e. generally the longest planned formation).

EMU/DMU and highspeed trainsets with multiple brake control architecture shall be tested in all operating modes (e.g.: UIC brake pipe, direct ep-brake, rescue- or towing-mode, etc.).

6.1.5 Testing of vehicles/trains with additional brake equipment

Typically additional brake equipments for service and/or emergency brake applications include: dynamic brake, eddy current brake, EP assist, magnetic track brake, brake pipe accelerators.

The testing defined in 6.1.4 shall be undertaken with all brake equipment operational.

If additional brake equipment is used in emergency brake or service brake, additional testing should be performed to determine brake performance with this equipment isolated.

If more than one additional equipment is fitted, there should be further testing to determine the contribution of each equipment.

6.2 Load conditions for tests

6.2.1 Freight wagons

For freight wagons with empty/load devices, slip tests shall be conducted:

— with minimum load (empty freight wagons), in the “empty” position;

— in the “empty” position with a load at the changeover mass. When an automatic “empty-loaded” changeover device is being used, the tests shall be carried out in the “empty” position with a load close to the changeover mass, but far enough below it to ensure that the automatic changeover device remains stable in the “empty” position;

— with normal load in the “loaded” position (EN 15663: Design mass under normal payload).

For freight wagons with self-adjusting load-proportional braking, the slip tests shall be conducted:

— with minimum load (empty freight wagons);

— in the lowest load status under which the maximum braked weight is achieved;

— at the condition at which the maximum energy is dissipated (combination of speed and load).

For S and SS freight wagons, as defined in EN 14198, the load definition leads to Table 3.

Table 3 — Load conditions for slip tests with S and SS freight wagons

Vehicle mass	Freight wagon for S-regime with empty-loaded changeover device (S1 in EN 14198)	Freight wagon for S-regime with self-adjusting load-proportional (S2 in EN 14198)	Freight wagon for SS-regime
Minimum load	x	x	x
Changeover mass	x		
14,5 t / wheelset		x	
18 t / wheelset			x
20 t / wheelset			x
22,5 t / wheelset	x	x	
x mandatory tests			
NOTE The values of the vehicle weight are typical values for UIC S-Regime or SS-Regime for tread-braked wheels.			

6.2.2 Locomotives

For locomotives only minimum load shall be tested.

6.2.3 Passenger vehicles

Load condition for passenger vehicles is specified in Table 4.

Table 4 — Load condition for testing

Vehicle type	Load status		
	Minimum load	**Normal load**	Maximum braking load
Coach, passenger trains, multiple unit and high speed train without load-proportional braking	X	X	(x)[a]
Coach, passenger trains, multiple unit and high speed train with load-proportional braking	X	X	X[a]
(x) Recommendation X Requirement			
a If difference between normal load and maximum braking load is more than 10 % of the normal load.			

In cases where loading is not possible, alternative methods are permitted, such as simulation by isolating other brake units, as long as this introduces no significant errors into the procedure. In particular, it shall